Chapter 10

The Insectivores of the Réserve Spéciale d'Anjanaharibe-Sud, Madagascar

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Abstract

Insectivores were surveyed on the eastern slopes of humid forest in the Réserve Spéciale d'Anjanaharibe-Sud at four elevational zones between 875 and 1950 m. Eleven species of tenrecs (*Setifer*, *Tenrec*, and nine species of *Microgale*) were documented within the reserve. An additional four species were also recorded on the western side of the reserve.

No species of insectivore occurred across the complete elevational transect. *Setifer setosus* and *Microgale principula* were restricted to the 875 m zone. The greatest species richness was found at 1260 and 1550 m with seven species of Tenrecidae (all *Microgale*). *Microgale dobsoni* was captured only at 1260 m. *Microgale soricoides*, *M. talazaci*, and *M. gymnorhyncha* were found in montane forest at 1260 and 1550 m, whereas *M. parvula* and *M. cowani* occurred in these two zones and approaching the summit at 1950 m. One species collected in montane forest of the reserve appears to be unrecognized and is described herein. Combining all sources of information, 16 species of Insectivora have been recorded within the reserve, 12 of which belong to the genus *Microgale*.

Résumé

Une enquête sur les insectivores de quatre zones situées sur un transect altitudinal entre 875 et 1950 m le long du versant oriental de la forêt humide sempervirente de la Réserve Spéciale d'Anjanaharibe-Sud a été réalisée. Onze espèces de tenrecs (*Setifer*, *Tenrec*, et neuf espèces de *Microgale*) ont été trouvées dans la réserve. Quatre espèces supplémentaires de *Microgale* ont été répertoriées sur le versant occidental de la réserve.

Aucune espèce d'insectivore n'a été trouvée sur l'ensemble des stations du transect altitudinal. *Setifer setosus* et *Microgale principula* présentaient une distribution restreinte à la station située à 875 m d'altitude. La plus grande diversité spécifique a été rencontrée à 1260 et 1550 m avec un total de sept espèces de Tenrecidae (toutes appartenant au genre *Microgale*). *Microgale dobsoni* était capturée seulement à 1260 m d'altitude, *Microgale soricoides*, *M. talazaci*, et *M. gymnorhyncha* ont été trouvées dans la forêt d'altitude à 1260 et 1550 m, alors que *M. parvula* et *M. cowani* étaient rencontrées dans ces deux zones et atteignaient presque les zones sommitales en étant présentes à 1950 m d'altitude. Une espèce collectée dans la forêt d'altitude de cette réserve semble être une nouvelle espèce et fait ici l'objet d'une description. En combinant toutes les sources d'information, 16 espèces d'insectivores ont été inventoriées au sein de la réserve, parmi lesquelles 12 appartiennent au genre *Microgale*.

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Introduction

Before the current study, little was known about the small mammal community of the Réserve Spéciale (RS) d'Anjanaharibe-Sud. The only Insectivora listed by Nicoll and Langrand (1989) for the reserve are members of the endemic family Tenrecidae, *Tenrec ecaudatus* (Schreber, 1777) and *Setifer setosus* (Schreber, 1777). The Soricidae, the other family of Insectivora found in Madagascar, represented on the island by *Suncus madagascariensis* (Coquerel, 1848) and the introduced *Suncus murinus* (Linnaeus, 1766) has not been recorded from the reserve. In the nearby Réserve Naturelle Intégrale (RNI) de Marojejy, a high mountain zone just across the Andapa basin from the RS d'Anjanaharibe-Sud, *T. ecaudatus*, *Setifer setosus*, *Hemicentetes semispinosus* (Cuvier, 1798), *Microgale talazaci* (Major, 1896a), *M. pusilla* (Major, 1896b), and *M. cowani* (Thomas, 1882) have been recorded (Nicoll & Langrand, 1989). During the Mission Franco-Anglo-Américaine, a site "1 day W of Andapa" was visited (Rand, 1936), and material of *M. talazaci* was collected and is now deposited in the Muséum National d'Histoire Naturelle, The Natural History Museum, and the American Museum of Natural History. Other than these records, little is known about the insectivore community in the general Andapa area.

The current report is based on a small mammal survey recently undertaken by S. M. Goodman in the RS d'Anjanaharibe-Sud from October to November 1994. The purpose of the present study was to document the distribution of Tenrecidae along an elevational gradient on the slopes of the RS d'Anjanaharibe-Sud, specifically with regard to altitudinal distribution, density, and species richness of *Microgale* (Thomas, 1882).

The genus *Microgale* is the most speciose of the tenrec genera endemic to Madagascar. The genus was revised by MacPhee (1987), who established an effective taxonomy based chiefly on dental morphology. During recent small mammal surveys (Raxworthy & Nussbaum, 1994; Goodman et al., 1996), numerous samples of *Microgale* were collected, further increasing knowledge and allowing additional refinement of the taxonomy of the genus (Jenkins et al., 1996, 1997).

The RS d'Anjanaharibe-Sud survey commenced in lowland forest at 875 m, progressing to montane forest at 1260 and 1550 m and to upper montane forest at 1950 m. Only one species of *Microgale*, *M. principula* (Thomas, 1926), was collected at the lower altitude, while eight other species were found in the montane and upper montane zones. Information on these nine species, including one believed to be undescribed, as well as other species of Tenrecidae found within the reserve, is given below.

Materials and Methods

Two principal techniques were used to trap insectivores in the four surveyed transect zones (at 875, 1260, 1550, and 1950 m above sea level): pitfall traps and standard small mammal live traps. The pitfall traps were composed of 11 plastic buckets (275 mm deep, 290 mm top internal diameter, and 220 mm bottom internal diameter), sunk in the ground at 10 m intervals with the upper rims flush with ground surface level. Small holes (2 mm diameter) were drilled in the bottom of the buckets to allow water drainage. A black plastic drift fence, 100 m long and 0.5 m high, was erected in a vertical position and stapled to thin wooden stakes. The fence bottom was buried 50 mm into the ground using leaf litter or soil and positioned to run across the middle of each pitfall trap. Pitfall buckets were positioned at 10 m intervals. Within each elevational zone, three lines were installed (valley bottom, slope, and ridge crest). Each line was checked in the morning soon after dawn and again in the late afternoon. After rain the buckets were sponge-dried. A bucket in place for a 24-hr period is referred to as a "bucket-day" (dawn to dawn). This is the same technique we have systematically used over the past few years in Madagascar (Raxworthy et al., 1994; Jenkins et al., 1996; Raxworthy & Nussbaum, 1996). The period of the survey coincided with the season when all tenrecs are presumed to be active (Stephenson, 1994).

In each elevational zone surveyed, trap lines were in operation for a minimum of five nights. Each trap line consisted of Sherman live traps ($9 \times 3.5 \times 3$ inches) and National live traps ($16 \times 5 \times 5$ inches) in a ratio of 4:1. Traps were baited daily, generally between 15:00 and 17:00 hr, with a fresh mixture of finely ground peanut butter and corn grain mixed in proportions to make a paste. Traps were visited at least twice per day, once at dawn and in the late afternoon. A "trap-night" is defined as one trap in use for a 24-hour period (dawn to dawn).

Captured animals were either released or prepared as standard museum skins with associated skulls and skeletons, fluid-preserved carcasses, or full skeletons. Voucher specimens are deposited in the Field Museum of Natural History, Chicago, and the Departément de Biologie Animale, Université d'Antananarivo, Antananarivo.

Measurements

Cranial measurements were taken using dial calipers and a microscope measuring stage. The dental nomenclature follows that of Mills (1966), Swindler (1976), Butler and Greenwood (1979), and MacPhee (1987). Dental notations are given in parentheses in the text; premaxillary and maxillary teeth are denoted by uppercase letters, and mandibular teeth are denoted by lowercase letters. The following measurements were made of specimens in the flesh or from prepared crania. Abbreviations and definitions for these measurements (all in millimeters with the exception of weight, which is in grams) are as follows:

BB = breadth of braincase, the greatest distance measured across the squamosals
CIL = condyloincisive length, cranial length from first upper incisor to occipital condyle
EL = ear length, measured from the notch at the base of the ear to the distalmost edge of the pinna
HB = head and body length, measured from the tip of the nose to the distalmost point of the body (at base of tail)
HF = hindfoot length, measured from the back edge of the heel to the tip of the longest toe (not including claw)
I1–P3 = length of anterior upper teeth, from anterior of first upper incisor to anterior of second upper premolar
TL = tail length, measured from the base of the tail (at right angles to the body) to the end of the distalmost vertebra; does not include terminal hair tufts
TOTL = total length of body and tail, measured from the tip of the nose to the end of the distalmost tail vertebra; animal is positioned on its back straight with vertebrae parallel to ruler but not stretched out
UTL = upper toothrow length, from anterior of first upper incisor to posterior of third upper molar, parallel to the long axis of the skull
WT = weight, measured in grams with Pesola spring scales; animals weighing less than 10 g were weighed to within 0.2 g, and those weighing between 10 and 100 g were weighed to within 0.5 g

Reproductive condition was recorded for males as length × width of the testes and degree of convolution of the epididymis. Females were noted as nonperforate or perforate and as nonparous or parous, and the number and location of any embryos and placental scars were recorded. The mammary formula is presented as the number of paired axial, abdominal, or inguinal teats.

The following age classes are recognized: "Infant" includes individuals in which the deciduous antemolar dentition and the molars are not fully erupted; the premaxillary, parietal, and basioccipital sutures are unfused. "Juvenile" includes individuals in which the molars are fully erupted and the deciduous antemolar dentition is erupted and in the process of replacement by the permanent teeth; cranial sutures are in the process of fusing. The eruption sequence of the permanent teeth has been subdivided into four stages by MacPhee (1987); these stages have been accepted in this chapter unless otherwise stated. "Adult" includes individuals with fully erupted permanent dentition; cranial sutures are generally fused, although their position is more or less clearly marked.

Other abbreviations used are as follows:

PN = Parc National
RNI = Réserve Naturelle Intégrale
RS = Réserve Spéciale
BM(NH) = Natural History Museum, London (formerly British Museum (Natural History)
FMNH = Field Museum of Natural History, Chicago
MCZ = Museum of Comparative Zoology, Harvard
MNHN = Muséum National d'Histoire Naturelle, Paris
UMMZ = University of Michigan, Museum of Zoology, Ann Arbor
C/c = canine
d = deciduous
I/i = incisor
M/m = molar
P/p = premolar

Systematic Section

Subfamily Tenrecinae
***Setifer setosus* (Schreber, 1777)**

HOLOTYPE—Unknown.

TYPE LOCALITY—Madagascar.

REFERRED MATERIAL—FMNH 154033, 154034, 154230, 154231, 154232, 154233, 154234, 154235: 6.5 km SSW of Befingitra, 14°45′S, 49°30′E, 875 m.

KEY FEATURES (see Appendix 10-1, p. 161)—Dorsum covered with spines. Skull moderately robust, dorsal profile curved in lateral view; rostrum deep and broad; interorbital region broad and elongated; braincase short, supraoccipital crest present. Two lower incisors present; dental formula 2/2 1/1 3/3 3/3 = 36; first upper incisors well developed, slightly shorter than upper canines; short diastemata on either side of upper canines and first lower premolar.

POPULATION STRUCTURE AND REPRODUCTION—The sex ratio of females to males was 1:4. Mammary formula: 1-2-2 (n = 2).

REMARKS—At 875 m four *Setifer* were obtained in pitfall traps; five individuals were obtained in live traps. All of the latter group were captured on the ground, generally in areas with thick ground leaf litter. Nicoll and Langrand (1989) previously reported this species from the reserve. It has a broad range across the island from Antsiranana to the Tolagnaro and Toliara regions.

***Tenrec ecaudatus* Schreber, 1777**

HOLOTYPE—Unknown.

TYPE LOCALITY—Madagascar.

KEY FEATURES (see Appendix 10-1, p. 161)—The largest of the Tenrecinae. Dorsal pelage of coarse, bristly hair intermixed with spines. Skull elongated; rostrum with deep sockets in ventrolateral region of the premaxillae, which accommodate the lower canines when the jaw is closed; interorbital region narrow, elongated; braincase short, narrow, angular, pronounced sagittal and supraoccipital crests form deep posterodorsal flanges. Three lower incisors present; dental formula 2/3 1/1 3/3 3/3 = 38; upper and lower canines very long, robust, and prominent; pronounced diastemata on either side of upper canines and posterior to lower canines; short diastemata posterior to first upper and lower premolars.

REMARKS—This widespread species was observed on two occasions at 875 m and thrice at 1260 m. No specimen was collected. Nicoll and Langrand (1989) also reported this species from the reserve.

***Microgale cowani* Thomas, 1882**

HOLOTYPE—BM(NH) 82.3.1.25, adult female body in alcohol, skull extracted, collected mid-March to mid-February 1880 by the Reverend W. Deans Cowan.

TYPE LOCALITY—Ankafana Forest, eastern Betsileo (Ankafana = Ankafina, Fianarantsoa, and Fianarantsoa Province, 21°12′S, 47°12′E; see MacPhee, 1987; Carleton & Schmidt, 1990).

REFERRED MATERIAL—FMNH 154020, 154021, 154022, 154195: 9.2 km WSW of Befingitra 14°44′S, 49°27′E, 1260 m; FMNH 154023, 154024, 154025, 154026, 154196, 154197, 154198, 154199, 154200, 154201, 154204: 11 km WSW of Befingitra, 14°44′S 49°26′E, 1550 m; FMNH 154202, 154203, 154205, 154206, 154207: 12.2 km WSW of Befingitra, 14°44′S, 49°26′E, 1950 m.

KEY FEATURES (see Table 10-1 and Appendix 10-2, p. 161)—Medium-sized *Microgale*, tail moderately short, shorter or subequal to HB. Pelage dark brown dorsally, gray ventrally with a reddish brown wash; tail bicolored, dark brown dorsally, sharply demarcated from paler reddish buff venter. Skull medium in size, rostrum elongated; pronounced diastemata separate teeth of upper anterior dentition from first upper incisor (I1) to second upper premolar (P3), also on either side of lower canine (c) and first lower molar (p2). All elements of talonid of third lower molar (m3) present, including hypoconid, entoconid ridge, talonid basin, and entoconid.

MEASUREMENTS—External and cranial measurements are presented in Table 10-1.

VARIATION—No interpopulation variation in size or pelage color was observed.

POPULATION STRUCTURE AND REPRODUCTION—The sex ratio of females to males was 1:1.5. The ratio of adults to juveniles was 1:1.5. Juveniles were not significantly smaller than adults in body or cranial size, although they were clearly lighter in body weight (see Table 10-1). All but one of the juveniles were dentally immature, with all molars fully erupted and either with a fully deciduous anterior dentition or only the third incisors in the process of replacement (stage 1 of MacPhee, 1987:13); the exception was a specimen at stage

TABLE 10-1. Dimensions of *Microgale* from RS d'Anjanaharibe-Sud.*

Taxon	HB	TL	HF	EL	WT	CIL	UTL	BB
Microgale cowani								
Adults	77–87	60–75	15–17	13–16	11.5–16.0	22.3, 22.8	10.6, 10.8	10.1, 10.3
	82.4 ± 3.00	66.3 ± 4.43	16.0 ± 0.71	14.5 ± 1.00	12.8 ± 1.41			
	(8)	(7)	(8)	(8)	(8)	(2)	(2)	(2)
Juveniles	73–87	61–76	15–17	14–16	9.5–11.5	22.0–22.9	10.2–10.6	9.7–10.4
	79.4 ± 4.65	67.3 ± 4.76	16.3 ± 0.62	14.4 ± 0.64	10.5 ± 0.72	22.4 ± 0.31	10.5 ± 0.14	10.0 ± 0.27
	(12)	(12)	(11)	(12)	(12)	(5)	(5)	(5)
Microgale longicaudata								
Adults	72, 74	148, 151	17	15	8.0, 9.5	21.3, 21.5	10.2, 10.4	8.7, 9.1
	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
?long./maj.† Juveniles	65	149	18	18	5.5	19.2	9.1	8.0
	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Microgale principula								
Juveniles	79, 80	151, 171	19	15, 16	8.5, 10.5	22.7, 23.2	10.1, 10.8	9.3, 9.4
	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Microgale parvula								
Adults	58–61	51–60	10	8–9	3.1–3.9	16.0–16.8	7.3–7.6	6.5–6.7
	60.3 ± 1.30	55.5 ± 3.35	10 ± 0	8.75 ± 0.43	3.4 ± 0.33	16.3 ± 0.32	7.4 ± 0.11	6.6 ± 0.08
	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Juveniles	58	54	10	8	2.4	15.7	7.1	6.7
	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Microgale dobsoni								
Adults	100–111	102–128	21–24	16–19	20.5–30	28.8–31.3	14.2–15.6	10.9–11.4
	104 ± 3.96	114.7 ± 7.8	22.3 ± 1.03	17.9 ± 0.99	25.5 ± 2.77	30.1 ± 0.72	15.2 ± 0.43	11.3 ± 0.16
	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)
Juveniles	101–112	112–120	22–23	18–19	23.5–31.5			
	106.7 ± 4.50	115.3 ± 3.40	22.7 ± 0.47	18.3 ± 0.47	26.7 ± 3.47			
	(3)	(3)	(3)	(3)	(3)			
Microgale talazaci								
Adults	107–124	126–144	23–26	19–20	31.5–39.5	34.8–36.0	17.3–18.1	12.2–12.7
	113.3 ± 6.57	136.6 ± 6.25	24.6 ± 1.02	19.4 ± 0.49	36.0 ± 2.87	35.4 ± 0.43	17.8 ± 0.29	12.4 ± 0.18
	(4)	(5)	(5)	(5)	(4)	(4)	(4)	(4)
Microgale soricoides								
Adults	85–103	84–97	17–18	15–17	16–22	25.5–26.3	12.4–12.8	10.6–11.1
	90.4 ± 6.80	92.6 ± 4.63	17.4 ± 0.49	16 ± 0.63	19.2 ± 2.06	25.9 ± 0.29	12.6 ± 0.15	11.0 ± 0.22
	(5)	(5)	(5)	(5)	(5)	(4)	(4)	(4)
Juveniles	84	94	17	15	14	25.6	12.1	11.0
	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

(*cont.*)

Table 10-1. *Continued.*

Taxon	HB	TL	HF	EL	WT	CIL	UTL	BB
Microgale gymnorhyncha								
Adults	100, 101 (2)	63, 71 (2)	16, 18 (2)	14, 15 (2)	17.5, 20 (2)	27.1, 27.7 (2)	13.8, 14.5 (2)	11.0, 11.3 (2)
Juveniles	84–94 88.8 ± 3.96 (4)	62–70 65.3 ± 2.95 (4)	17–18 17.5 ± 0.5 (4)	13–14 13.5 ± 0.5 (4)	11.5–16.5 14 ± 2.5 (4)	24.6–27.4 26.2 ± 1.15 (4)	13.2–14.5 13.8 ± 0.52 (4)	10.3–10.5 10.4 ± 0.07 (4)
Microgale monticola								
Adults	81–92 85.8 ± 4.35 (5)	105–113 109.5 ± 2.43 (6)	20–21 20.8 ± 0.37 (6)	15–16 15.7 ± 0.47 (6)	13.5–17.5 15.5 ± 1.38 (5)	25.5–25.8 25.7 ± 0.12 (5)	12.4–12.8 12.6 ± 0.15 (5)	10.5–11.1 10.9 ± 0.21 (5)
Infant	62 (1)	80 (1)	19 (1)	12 (1)	7.5 (1)	20.6 (1)		9.8 (1)

* Measurements are given as the range, followed by the mean ± SD and the sample size (in parentheses). See "Materials and Methods" for definitions of abbreviations. For samples of two or less only the measurements are presented.

† *Microgale longicaudata/majori.* See text (p. 144) for a discussion of this animal.

2, with the first and third incisors and the first and third premolars erupting. One adult female was lactating. Another female (FMNH 154021), despite having a fully deciduous anterior dentition and unfused premaxillary and basioccipital sutures, was reproductively adult because the mammae were slightly enlarged, two placental scars were present in the left oviduct, and one scar was present in the right oviduct. Mammary formula: 1-0-2 (n = 6).

Remarks—See Jenkins et al. (1996) for redefinition of this species and an augmented description. Given the taxonomic complications of the name "*cowani*" in the literature and the various treatments of its species limits (see MacPhee, 1987; Stephenson, 1995), it is difficult to assess the northern limit of *cowani.* However, on the basis of material we have examined and the redefinition of this species by Jenkins et al. (1996), the specimens from the RS d'Anjanaharibe-Sud mark the northern known limit of its range.

Microgale longicaudata Thomas, 1882

Microgale majori Thomas, 1918; MacPhee, 1987

Holotype—BM(NH) 82.3.1.15, adult female, body in alcohol, skull extracted, collected mid-March to mid-February 1880 by the Reverend W. Deans Cowan.

Type Locality—Ankafana Forest, eastern Betsileo (Ankafana = Ankafina, Fianarantsoa, and Fianarantsoa Province, 21°12′S, 47°12′E; see MacPhee, 1987; Carleton & Schmidt, 1990).

Referred Material—FMNH 154005: 9.2 km WSW of Befingitra, 14°44′S, 49°27′E, 1260 m; FMNH 154006: 11 km WSW of Befingitra, 14°44′S, 49°26′E, 1550 m; FMNH 154220: 12.2 km WSW of Befingitra, 14°44′S, 49°26′E, 1950 m.

Key Features (see Table 10-1 and Appendix 10-2, p. 161)—Small in size, tail very long, more than twice as long as HB; distal portion of tail naked and transversely wrinkled on dorsal surface; fifth hind digit elongated, subequal in length to second digit. Dorsal pelage reddish brown, venter gray with bright reddish buff or buff wash. Skull small, rostrum moderately short; braincase moderately narrow and long. Diastemata present between I1 and second upper molar (I2) and either side of upper canine (C) and first upper premolar (P2); well-developed anterior and posterior accessory cusps present on I2, C, and P2; C subequal to or taller than I1; third upper premolar (P4) scarcely greater in crown height than P3. Lower p2 caniniform. Talonid of m3 with low hypoconid, hypoconulid well developed, narrow talonid basin, reduced entoconid ridge, and entoconid absent.

MEASUREMENTS—External and cranial measurements are presented in Table 10-1.

VARIATION—Marked variation in size between populations was observed. Specimens from RS d'Anjanaharibe-Sud are larger than those from RNI d'Andringitra (see Jenkins et al., 1996) and PN de Mantady.

POPULATION STRUCTURE AND REPRODUCTION—The single juvenile had fully erupted molars but completely deciduous anterior dentition and unfused premaxillary and basioccipital sutures. Two adult females were collected during the survey; both were perforate, and one was lactating. Mammary formula: 1-0-2 (n = 1).

REMARKS—*Microgale longicaudata* is a widespread shrew tenrec known from scattered localities from PN de la Montagne d'Ambre in the north to the RNI d'Andringitra in the south (Jenkins et al., 1996). Although this sample is too small for valid conclusions, the size difference between the small juvenile (FMNH 154005) and the large adults (FMNH 154006 and 154220) appears greater than that likely to be attributable to growth. In addition, the adult specimens from RS d'Anjanaharibe-Sud, in common with those from Ankafina and Amboanara considered to represent *M. longicaudata* by Thomas (1918), are larger than those from RNI d'Andringitra, PN de Mantady, and the other specimens from Ankafina considered by Thomas to represent *M. majori*. Although MacPhee (1987) synonymized *M. majori* with *M. longicaudata*, this evidence tends to support the original view of Thomas (1918) that *M. majori* may be a separate species distinguishable by its smaller size from *M. longicaudata*.

The only individual of this species captured at 1550 m was obtained in a Sherman live trap placed on a moss-covered vine 1.5 m above the ground. In the literature on *Microgale longicaudata*, there has been speculation, based on external morphology (Thomas, 1918; Eisenberg & Gould, 1970; MacPhee, 1987) and skeletal structure (Dobson, 1882), that its long and modified tail might have some prehensile capabilities. We are now able to confirm this ability: a captive animal was able to dangle by the tip of its tail from a thin branch for at least 10 sec (see Fig. 10-1) using only the very distal tip of its tail to grip the branch.

Microgale longicaudata and *M. principula* share many presumed derived morphological adaptations, particularly the long prehensile tail, and have similar cranial and dental morphologies. Although no phylogenetic analysis of the genus has been conducted to date, we strongly suspect that these two taxa are closely related and fill similar ecological niches. On the slopes of the RS d'Anjanaharibe-Sud, these two species replace one another, with *principula* occurring in lowland forest and *longicaudata* on the higher slopes. We have no evidence that they occur in microsympatry on the mountain. To our knowledge, this is the second reported case of these two species occurring in close proximity; both species have also been recorded from PN de Mantady (see Jenkins, 1993).

Microgale principula Thomas, 1926

Microgale sorella Thomas, 1926; MacPhee, 1987

HOLOTYPE—BM(NH) 25.8.3.15, adult female, body in alcohol, skull extracted, collected by C. Lamberton.

TYPE LOCALITY—Midongy du Sud, SE Madagascar (Midongy Atsimo, 23°35′S, 47°01′E; see MacPhee, 1987).

REFERRED MATERIAL—FMNH 154003, 154004: 6.5 km SSW of Befingitra, 14°45′S, 49°30′E, 875 m.

KEY FEATURES (see Table 10-1 and Appendix 10-2, p. 161)—Medium-sized *Microgale*, tail very long, more than twice as long as HB; distal portion of tail naked and transversely wrinkled on dorsal surface; fifth hind digit elongated, subequal in length to second digit. Pelage distinctly bicolored, reddish brown dorsally, gray with buff wash ventrally. Skull medium in size, rostrum moderately short and broad, braincase moderately narrow. Short diastemata between I1 and I2, and on either side of C and P2, I2 and third upper incisor (I3) more or less in contact; well-developed anterior and posterior accessory cusps present on I2, C, and P2; I1 greater in crown height than C; P4 distinctly greater in crown height than P3. Lower p2 moderately caniniform. Talonid of m3 with low hypoconid, well-developed hypoconulid, broad talonid basin, reduced entoconid ridge, entoconid absent.

MEASUREMENTS—External and cranial measurements are presented in Table 10-1.

VARIATION—The sample is too small for meaningful comments on variation.

POPULATION STRUCTURE AND REPRODUCTION—

FIG. 1. Photograph of *Microgale longicaudata* (FMNH 154005) captured in the 1260 m zone and hanging suspended by its distally prehensile tail. The photograph was staged in the sense that the animal's tail was manipulated as the single point of contact with the branch. Once the animal was released in this position, it was able to remain suspended for more than 10 sec. (Photograph by Brian Fisher.)

The sample contained two juveniles, one at stage 2 and the other at stage 3 of dental development (MacPhee, 1987); the sex ratio was 1:1. The testes of FMNH 154004, in which P3 and p3 were erupting, measured 7 × 5 mm with a convoluted epididymides, so the specimen was probably reproductively active while still retaining some deciduous teeth.

REMARKS—This species was previously known to occur from the RS d'Ambatovaky (16°51′S, 49°08′E) in the north-central portion of the eastern humid forest (Jenkins, 1992) to the Grotte d'Andrahomana in the extreme south (MacPhee, 1987). The specimens from the RS d'Anjanaharibe-Sud mark the most northerly locality to date from which this species has been recorded.

Microgale parvula G. Grandidier, 1934

Microgale pulla Jenkins, 1988

HOLOTYPE—MCZ 45465, juvenile male, body in alcohol, skull extracted, collected by M. Drouhard.

TYPE LOCALITY—Environs of Diego-Suarez (Antsiranana, ca. 12°16′S, 49°18′E, see MacPhee, 1987; probably Montagne d'Ambre, see Jenkins et al., 1997).

REFERRED MATERIAL—FMNH 154007, 154217: 9.2 km WSW of Befingitra, 14°44′S, 49°27′E, 1260 m; FMNH 154008: 11 km WSW of Befingitra, 14°44′S, 49°26′E, 1550 m; FMNH 154218, 154219: 12.2 km WSW of Befingitra, 14°44′S, 49°26′E, 1950 m.

KEY FEATURES (see Table 10-1 and Appendix 10-2, p. 161)—Very small, TL slightly shorter than HB. Dorsal pelage dark brown, ventral pelage dark gray-brown, tail uniform dark gray. Skull very small and delicate, rostrum slender, braincase shallow and long, occipital condyles posterodorsally orientated. Diastemata between I1 and I2 and either side of C and P2; anterior and posterior accessory cusps present on I2, I3, and P2. Diastema between c and p2. Talonid of m3 with well-developed hypoconulid but reduced hypoconid, entoconid and entoconid ridge, and narrow, shallow talonid basin.

Measurements—External and cranial measurements are presented in Table 10-1.

Variation—There is no obvious interpopulation variation in size or pelage coloration.

Population Structure and Reproduction—The sample contained four adults and one juvenile, and the sex ratio of females to males was 1: 1.5. The juvenile, which had a fully deciduous anterior dentition, was within the size range of the adults in most dimensions, except body weight, CIL, and UTL, in which it was smaller (see Table 10-1). One of the two adult females was lactating, both were perforate, and the mammary formula was 1-0-2 (n = 1). The testes of one adult male measured 3 × 2 mm with convoluted epididymides.

Remarks—See Jenkins et al. (1996; 1997) for redefinition and augmented description of this species as well as for information on its range. This species is now known from the far north in the PN de la Montagne d'Ambre (Raxworthy & Nussbaum, 1994) to the extreme southern limit of the eastern humid forest in the Vohimena Mountains (UMMZ) and Anosyenne Mountains (FMNH).

Microgale dobsoni Thomas, 1884

Nesogale dobsoni Thomas, 1918

Holotype—BM(NH) 84.10.20.1, immature male, in alcohol, skull extracted. Collected February or March 1884 by W. Waters.

Type Locality—Nandésen forest, Central Betsileo (Nandihizana, 10 miles S of Ambusitra, manuscript note in Thomas' private copy of original description, archived in BM(NH); Nandihizana, ca. 20 miles (30 km) SSW of Ambositra, see MacPhee, 1987; estimated as ca. 20°50'S, 47°10'E).

Referred Material—FMNH 154015, 154016, 154208, 154209, 154210, 154211, 154212, 154213, 154214, 154215: 9.2 km WSW of Befingitra, 14°44'S, 49°27'E, 1260 m.

Key Features (see Table 10-1 and Appendix 10-2, p. 161)—Large, TL subequal to or longer than HB. Dorsal pelage brown, venter gray with buff wash. Skull large and robust, sutures fused and obscure; rostrum moderately broad, interorbital region long; braincase angular, superior articular facets very prominent, supraoccipital crests well developed; occipital region reduced. Diastemata between I1 and I2 and between I3 and C. Upper I1 larger than I2, i2 considerably larger than canine. Talonid of m3 reduced, hypoconid low, hypoconulid prominent, entoconid ridge and talonid basin poorly defined, entoconid absent.

Measurements—External and cranial measurements are presented in Table 10-1.

Variation—No obvious variation in size is evident.

Population Structure and Reproduction—The ratio of juveniles to adults in the sample was 1:2.3, and the sex ratio was 1:1. There was no indication of sexual dimorphism in size in this small sample, except in body weight, where the females were notably heavier (20.5–25.5, mean 23.8 ± 2.05, n = 4 for males; 26.0–30.0, mean 27.8 ± 1.65, n = 3 for females), although the sample is too small to be statistically significant. The size range of adults and juveniles was similar, although the range and mean in body weight of the juveniles actually exceeded that of the adults (see Table 10-1); it is suggested that this may be an anomalous result due to the small sample size. One of the adult females was lactating and had two placental scars in the left oviduct and three scars in the right oviduct. Mammary formula: 1-1-2 (n = 5).

Remarks—Two of the *Microgale dobsoni* obtained in the 1260 m zone were captured in Sherman traps. Both were taken on consecutive nights in the same trap placed on the ground next to a small tree with a hole in the base. One *M. talazaci* was taken in the same trap set, which shows that these two species, at least on occasion, have overlapping home ranges.

This species is widespread and is now known from Manohilahy, 17°16'S, 48°01'E (Eisenberg & Gould, 1970), to Antampona (MacPhee, 1987). The specimens from the RS d'Anjanaharibe-Sud mark the northernmost record to date. This species and *M. talazaci*, the largest shrew-tenrecs, are known to be sympatric at several sites, including RS d'Analamazaotra (Eisenberg & Gould, 1970), RS d'Ivohibe (MacPhee, 1987), and on the Ankaratra Massif (BM(NH), FMNH, and MNHN).

Microgale talazaci Major, 1896a

Nesogale talazaci Thomas, 1918

Holotype—BM(NH) 97.9.1.107, adult female, skin, skull, and skeleton. Collected 22 May 1896 by C. I. Forsyth Major.

Type Locality—Forest of the Independant Tanala of Ikongo, in the neighborhood of Vinanitelo, 1 day's journey S of Fianarantsoa, 21°44'S, 47°16'E.

REFERRED MATERIAL—FMNH 154017, 154224, 154225, 154226: 9.2 km WSW of Befingitra, 14°44′S, 49°27′E, 1260 m; FMNH 154018: 11 km WSW of Befingitra, 14°44′S, 49°26′E, 1550 m.

KEY FEATURES (see Table 10-1 and Appendix 10-2, p. 161)—Very large, TL longer than HB. Dorsal pelage brown, venter gray with reddish buff wash. Skull very large and robust, sutures fused and obscure; rostrum broad, interorbital region long, parallel sided; braincase angular, short relative to cranial length, superior articular facets very prominent, supraoccipital crests well developed, occipital region very reduced, occipital condyles visible in dorsal view. Small diastemata between I1 and I2 and between I3 and C. Upper I1 larger than I2, i2 considerably larger than canine. Talonid of m3 reduced, hypoconid low, hypoconulid well marked, entoconid ridge and talonid basin poorly defined, entoconid absent.

MEASUREMENTS—External and cranial measurements are presented in Table 10-1.

VARIATION—There is no obvious variation in size.

POPULATION STRUCTURE AND REPRODUCTION—The sample consisted of five adults, with a sex ratio of 1:3 (females to males). The testes of two males measured 5 × 3 mm and 10 × 6 mm, both with convoluted epididymides. The female was perforate, with a mammary formula of 1-1-2.

REMARKS—At 1260 m one *Microgale talazaci* was trapped in a Sherman trap placed on the ground at the base of a small tree with a hole in its base. The only individuals of this species captured within the 1550 m elevational zone were taken on the ground in Sherman live traps; one individual was collected in a trap placed at the opening of a small hole under a large boulder, and a second individual was collected at the base of a small tree with a cavity under the roots. *Microgale talazaci* is known from humid forests at a range of elevations from the Antsiranana region south to Vondrozo (MacPhee, 1987) and west to the Sambirano (BM(NH)).

Microgale soricoides Jenkins, 1993

HOLOTYPE—BM(NH) 91.565, adult male in alcohol, skull extracted. Collected 13 April 1991 by C. J. Raxworthy.

TYPE LOCALITY—Mantady National Park (PN de Mantady), ca. 15 km north of Périnet (Andasibe), 18°51′S, 48°27′E, in primary rain forest, 1100–1150 m.

REFERRED MATERIAL—FMNH 154027, 154029, 154221, 154222, 154223: 9.2 km WSW of Befingitra, 14°44′S, 49°27′E, 1260 m; FMNH 154030: 11 km WSW of Befingitra, 14°44′S, 49°26′E, 1550 m.

KEY FEATURES (see Table 10-1 and Appendix 10-2, p. 161)—Size large, TL subequal to or longer than HB. Pelage light buff brown dorsally, gray-brown ventrally with reddish buff wash. Skull moderately large and robust, rostrum and interorbital region broad, braincase short and broad; supraoccipital ridge present. First I1 markedly robust and pro-odont. First i1 and i2 robust and procumbent, i2 smaller than i1 but larger than c. First upper and lower premolars very small with a single root. Talonid of m3 reduced to very low hypoconid, oblique crest, and prominent hypoconulid.

MEASUREMENTS—External and cranial measurements are presented in Table 10-1.

VARIATION—There is no evidence of size variation in the small sample available.

POPULATION STRUCTURE AND REPRODUCTION—The age structure in the sample consisted of one juvenile with a fully deciduous anterior dentition and five adults, and the sex ratio (males to females) was 1:2. In size, the juvenile was at the lower part of the adult range and weighed less than any of the adults (see Table 10-1). One adult male had testes measuring 5 × 5 mm with convoluted epididymides. Mammary formula: 1-0-2 (n = 1); 1-1-2 (n = 2).

REMARKS—This species is now known from three localities, the type locality in the PN de Mantady (18°51′S, 48°27′E), the RNI d'Andringitra (Jenkins et al., 1996), and the RS d'Anjanaharibe-Sud, which marks the northernmost record to date.

Microgale gymnorhyncha Jenkins, Goodman and Raxworthy 1996

Microgale gracilis (Major): MacPhee, 1987, in part

HOLOTYPE—FMNH 151807, adult female in alcohol, skull extracted (field number SMG 6697), collected 13 December 1993 by S. M. Goodman and C. J. Raxworthy.

TYPE LOCALITY—38 km S of Ambalavao, RNI d'Andringitra, on ridge E of Volotsangana River, Fianarantsoa Province, 22°11′39″S, 46°58′16″E, 1625 m.

REFERRED MATERIAL—FMNH 154028, 154216: 9.2 km WSW of Befingitra, 14°44′S, 49°27′E, 1260 m; FMNH 154009, 154010, 154011, 154031: 11 km WSW of Befingitra, 14°44′S, 49°26′E, 1550 m.

KEY FEATURES (see Tables 10-1 and Appendix 10-2, p. 161)—Large, TL shorter than HB. Dorsal pelage dark brown, dark gray-brown ventrally. Muzzle very long, forming a proboscis; rhinarium very large with transversely striated naked region. Eyes very small. Ears small, virtually concealed in pelage. Forefeet broad, claws enlarged. Skull long, moderately gracile; rostrum slender and elongated; braincase short and broad. Dentition moderately reduced with long diastemata between all anterior teeth from I1 to P3 and i2 to p3; talonid of m3 slightly reduced; talonid basin, hypoconid, hypoconulid, and entoconid ridge present, entoconid indicated.

MEASUREMENTS—External and cranial measurements are presented in Table 10-1.

VARIATION—The pelage of juveniles is duller and grayer than that of adults, which are more speckled brown on the head and the anterior part of the dorsum. There is some evidence from the small samples available that specimens from RS d'Anjanaharibe-Sud average larger than those from RNI d'Andringitra (see Table 10-1 and Jenkins et al., 1996).

POPULATION STRUCTURE AND REPRODUCTION—The adult to juvenile ratio in the sample was 1:2, and the ratio of females to males was 1:1.5. The juveniles were all dentally immature, with the third molars still in the process of eruption in two specimens, whereas the other two had fully deciduous anterior dentitions but erupted molars. In size, the juveniles fell below or at the lower part of the adult range (see Table 10-1). One of the adult females contained one embryo in the left oviduct and two in the right oviduct, measuring 5 mm crown to rump length. Mammary formula: 1-0-2 (n = 2).

REMARKS—In the 1260 m elevational zone, one individual of this species was captured in a Sherman trap placed on the ground at a hole under tree roots. *Microgale gymnorhyncha* is known from three localities, the RNI d'Andringitra (the type locality), Fanovana (Jenkins et al., 1996), and the RS d'Anjanaharibe-Sud.

Microgale monticola, new species

HOLOTYPE—FMNH 154012 (field number SMG 7020), adult female, skin and skull, collected 15 November 1994 by Steven M. Goodman.

TYPE LOCALITY—11 km WSW of Befingitra, Réserve Spéciale d'Anjanaharibe-Sud, 14°44′S, 49°26′E, 1550 m.

PARATYPES—FMNH 154013, 154014, 154227: 11 km WSW of Befingitra, 14°44′S, 49°26′E, 1550 m; FMNH 154019, 154228, 154229: 12.2 km WSW of Befingitra, 14°44′S, 49°26′E, 1950 m.

DISTRIBUTION—Recorded to date only from the RS d'Anjanaharibe-Sud.

HABITAT—Collected in montane and upper montane forest, at an altitude of 1550–1950 m on wet ground in valley bottoms, on slopes dominated by bamboo, and on ridge crests.

DIAGNOSIS—Similar in size to *Microgale thomasi* but with tail longer than head and body. Pelage dark dorsally and ventrally. Skull moderately robust, interorbital region broad with frontals slightly dorsolaterally inflated. Upper and lower canines robust, upper and lower first premolars (P2 and p2) large; P2 with well-developed anterior and posterior accessory cusps, p2 anteroflexed.

DESCRIPTION—Moderately robust, medium-sized species of *Microgale* with tail longer than head and body (see Fig. 10-2, Tables 10-1, 10-2). Dorsal pelage dark brown and slightly grizzled; hairs with silvery gray bases, tops banded dark brown, then red-brown with dark brown tips; guard hairs with gray bases and long, dark brown tops. Ventral pelage dark brown; individual hairs with silvery gray bases but tops of some banded buff, then brown with buff tips, others with brown tops; guard hairs with gray bases and buff tops. Tail dark brown dorsally, paler ventrally; tail scale hairs sparse and short, approximately 1.5 mm scales in length, so scales are clearly visible. Feet dark brown. Forefeet moderately long and broad with well spaced cheiridia and moderately long claws; digits slightly lengthened. Hindfoot long with slightly elongated, well spaced cheiridia, slightly lengthened digits, heel naked with sparse, short hairs on lateral margins. The digits of fore- and hindfeet are similar in proportions, with the first digit reaching just beyond the base of the second and the fifth reaching the distal joint of the fourth digit. Skull moderately large (see Tables 10-1, 10-2, Fig. 10-3), rostrum moderately elongated, nasals terminate dorsal to the zygomatic plate, interorbital region broad with frontals slightly dorsolaterally inflated, parietals moderately large, braincase rounded, moderately broad, and deep, tapering slightly from anterior to posterior, supraoccipital crest absent; palate with posterior incisive foramina lying between I3, linked

FIG. 2. Dorsal view of skins of *Microgale monticola* (FMNH 154012) (**left**) and *M. thomasi* (BM(NH) 97.9.1.108) (**right**). Scale = 1 mm.

TABLE 10-2. Comparison of *Microgale monticola* and *M. soricoides* from RS d'Anjanaharibe-Sud and *M. thomasi* from eastern Madagascar.*

Character	*Microgale monticola*	*Microgale thomasi*	*Microgale soricoides*
Head and body length	81–92 85.8 ± 4.35 (5)	91–97 93.7 ± 2.49 (3)	85–103 90.4 ± 6.8 (5)
Tail length	105–113 109.5 ± 2.43 (6)	62–72 66 ± 4.3 (3)	84–97 92.6 ± 4.63 (5)
Ratio of tail length to head and body length	1.2–1.4 1.3 ± 0.07 (4)	0.7–0.8 0.7 ± 0.05 (3)	0.9–1.1 1.0 ± 0.07 (4)
Ratio of tail length to condyloincisive length	4.1–4.4 4.3 ± 0.10 (5)	2.4–2.7 2.5 ± 0.14 (3)	3.3–3.7 3.6 ± 0.16 (4)
Hindfoot length	20–21 20.8 ± 0.37 (6)	18.7–19 18.9 ± 0.14 (3)	17–18 17.4 ± 0.49 (5)
Condyloincisive length	25.5–25.8 25.7 ± 0.12 (5)	25.9–27.1 26.5 ± 0.51 (4)	25.5–26.3 25.9 ± 0.29 (4)
Braincase breadth	10.5–11.1 10.9 ± 0.21 (5)	11.2–11.6 11.4 ± 0.15 (4)	10.6–11.1 11.0 ± 0.22 (4)
Mandible length	17.3–17.5 17.4 ± 0.08 (5)	17.9–19.2 18.6 ± 0.52 (4)	17.0–17.3 17.2 ± 0.12 (4)
Mandible height at coronoid process	5.3–5.6 5.5 ± 0.1 (5)	6.0–6.5 6.3 ± 0.19 (4)	6.4–7.2 6.8 ± 0.29 (4)
Ascending ramus length	5.7 ± 6.0 5.8 ± 0.10 (5)	6.2–6.9 6.7 ± 0.29 (4)	6.0–6.6 6.3 ± 0.22 (4)

* Measurements are given as the range, followed by the mean ± SD and sample size (in parentheses).

to anterior incisive foramina by short commissures; posterior border of palatine broad and slightly curved, mesopterygoid anteriorly broad, tapering posteriorly (see Fig. 10-3), pterygoids narrow anteriorly, broader in midline, outer lateral margin curved. Mandible moderately robust, slightly sinuous, mental foramen lies below posterior root of p2 or between p2 and p3. Dentition (see Fig. 10-4) with short diastemata between anterior teeth from I1 to P2 or P3 and usually on either side of p2. First two upper incisors (I1, I2) with prominent distostyles, a small distostyle is present on third upper incisor (I3) and also canine (C), anterior accessory cusps may also be present on I2 and C; first upper premolar (P2) robust, double rooted with small, well marked anterior and posterior accessory cusps, and a distinct lingual cingulum with a small anterolingual cuspid is present; diastemata usually present between all of the anterior teeth from I1 to P3; anterior ectostyle of second upper premolar (P3) present but poorly differentiated from paracone, distostyle not differentiated; third upper premolar (P4) with prominent mesostyle and anterior ectostyle, distostyle present but poorly differentiated; upper molars as for the genus. Lower incisors as for the genus, with well-developed posterior cusps; no anterior cuspid on canine (c) but anterolingual cingulum present; first lower premolar (p2) robust, anteroflexed, tricuspid, double rooted, very similar in form and only slightly smaller than second lower premolar (p3); third lower premolar (p4) with a small cuspid on talonid; lower molars as for genus; hypoconid of third lower molar (m3) low, entoconid ridge present, entoconid absent, talonid basin present, narrow.

DECIDUOUS DENTITION—This is based on a single individual in which the deciduous dentition is not fully erupted. Deciduous upper and lower incisors, canines and premolars are similar to the

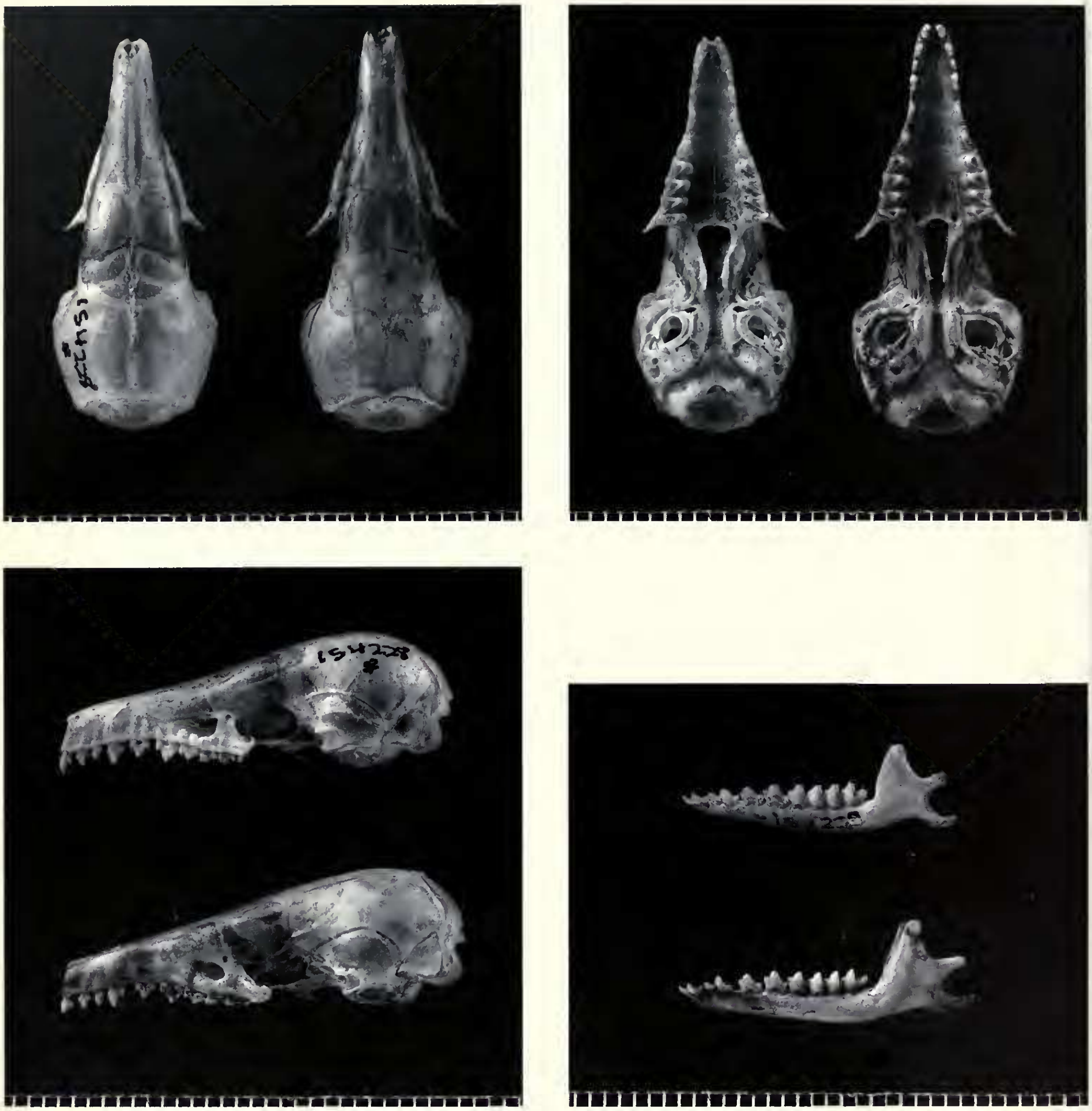

Fig. 3. Crania of *Microgale monticola* (FMNH 154228) and *M. thomasi* (BM(NH) 95.R26). Upper sets of photographs of *M. monticola* and *M. thomasi* (left to right) of dorsal and ventral views. Scale = 1 mm. Lower sets of photographs of *M. monticola* (top) and *M. thomasi* (lower) of left lateral views of skulls and mandibles. Scale = 1 mm.

permanent teeth but smaller; slight trace of metaconid on dp3. Because no juveniles were collected, no comments on the eruption sequence are possible.

Etymology—The name of the new species, *monticola*, Latin for "of the mountain," is derived from the montane habitat in which it occurs.

Comparisons—In comparison with other species of *Microgale* collected from RS d'Anjanaharibe-Sud, *M. monticola* is larger than *M. parvula* and *M. longicaudata*, averages larger than *M. cowani* and *M. principula*, but is smaller than *M. gymnorhyncha*, *M. dobsoni*, and *M. talazaci* (see Table 10-1). *Microgale monticola* differs from *M. cowani* in its greater tail length relative to that of head and body (ratio 0.7–0.9, mean 0.8 ± 0.07, n = 7 in *M. cowani*; ratio 1.2–1.4, mean 1.3 ± 0.07, n = 5 in *M. monticola*), longer hindfoot, and larger skull. It is readily distinguished from *M. principula*, which has an ex-

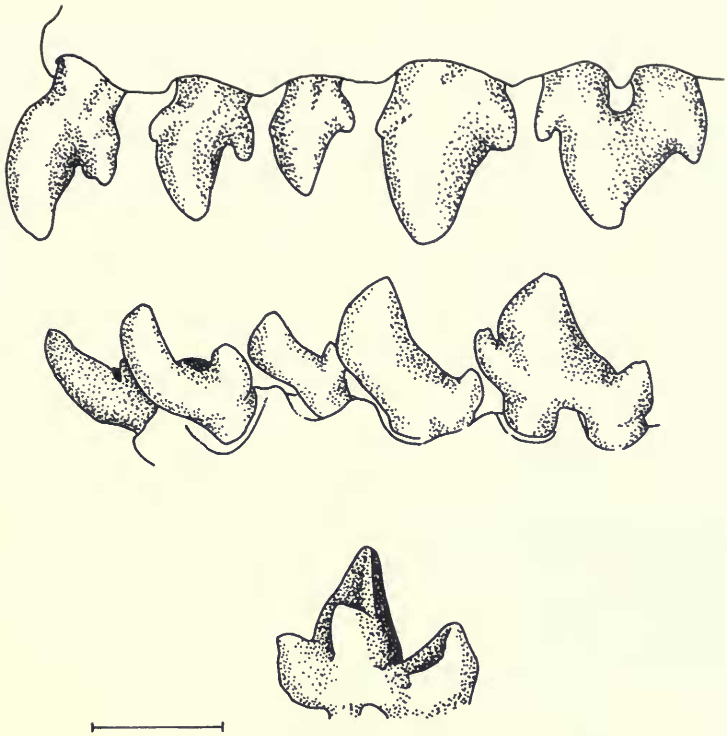

FIG. 4. Dentition of *Microgale monticola* (FMNH 154012). Buccal view of left I1–P2 (**top**), buccal view of left i1–p2 (**middle**), and lingual view of right m3 (**bottom**). Scale = 1 mm.

tremely long tail approximately twice as long as head and body length (ratio of tail to head and body length 2.1 in the subadult (FMNH 154004), (1.9 in the juvenile (FMNH 154003) *M. principula*). *Microgale monticola* is similar in body and cranial size to *M. soricoides*, although it averages slightly smaller (see Tables 10-1, 10-2); the two species are, however, discernable externally by the paler, buffy gray, more speckled dorsal pelage, reddish buff wash on the venter, and paler feet of *M. soricoides* and the longer hindfeet and greater relative tail length of *M. monticola*. In craniodental features these two species are readily distinguished. Cranially *M. monticola* is separated from *M. soricoides* by the slightly narrower rostrum (2.9–3.2; mean 3.1 ± 0.10, n = 5 in *M. monticola*; 3.2–3.8, mean 3.5 ± 0.22, n = 4 in *M. soricoides*), deeper occiput (3.4–3.9, mean 3.8 ± 0.21, n = 4 in *M. soricoides*; 4.5–4.7, mean 4.6 ± 0.08, n = 5 in *M. monticola*), and less robust mandible (see Table 10-2). The two species are dentally distinguished by the characteristically robust first upper and lower incisors and small, single-rooted upper and lower first premolars of *M. soricoides* in comparison with the unmodified upper and lower first incisors and large, double-rooted first premolars of *M. monticola*.

Of those species of *Microgale* recorded from elsewhere in Madagascar, *M. monticola* is easily distinguished on the basis of size and morphology, with the exception of *M. thomasi* (Major, 1896a), a species poorly represented in museum collections, so far recorded mostly from more southerly localities in the eastern rain forest. These two species are similar in body size and dental features (see Table 10-2, Figs. 10-2, 10-3). *Microgale thomasi* is paler, more rufous, and more speckled in dorsal coloration than *M. monticola*, with the venter distinctly paler than the dorsum and with a more definitely bicolored tail. *Microgale thomasi* is slightly larger and more robust in appearance, with the tail shorter than the head and body length and with shorter hindfeet, whereas *M. monticola* is readily distinguished by its long tail relative to the head and body length and longer hindfeet; the tail of *M. thomasi* has moderately long, dense scale hairs, particularly proximally, unlike the short scale hairs of *M. monticola*. In *M. monticola* the digits of the hindfeet are slightly elongated, with the first digit reaching beyond the basal phalange of the second digit, and the fifth digit reaching the base of the distal phalange of the fourth digit; the cheiridia are elongated and well spaced; the sole is naked apart from sparse, short hairs on the lateral margin of the tarsus. In contrast, the digits of *M. thomasi* are not elongated, the first digit barely reaches the first phalange of the second digit, the fifth digit only midway along the second phalange of the fourth digit; the cheiridia are rounded and closely grouped; the sole is clothed with short hairs. The cranial dimensions and morphology of the facial region of the crania of both species are very similar with greater differences evident in the posterior regions of the crania. The commissures linking the anterior and posterior incisive foramina are short and poorly defined, and the posterior incisive foramina are positioned between the third upper incisors in *M. monticola*, whereas in *M. thomasi*, the posterior incisive foramina lie between the posterior part of the canines and are linked to the anterior foramina via longer, well-defined commissures. In contrast to the morphology of the pterygoid region of *M. monticola*, in *M. thomasi* the posterior border of the palatine is narrow and rounded, the mesopterygoid region tapers only slightly from anterior to posterior, the pterygoid region is longer, and the outer lateral margin is more or less straight (see Fig. 10-3) (length of pterygoid region from posterior border of the palate to inferior articular facet 4.4–4.7, mean 4.6 ± 0.12, n = 5 in *M. monticola*; 5.1–5.6, mean 5.4 ± 0.21, n = 4 in *M. thomasi*). The basisphenoid is stepped between the anterior region of the tympanic bullae in *M. thomasi* but level in *M. monticola*. In dorsal view the shape of the braincase differs in the two species; that of *M. thomasi* is shorter, broader anteriorly and tapers more abruptly posteriorly, the parietal is noticeably shorter in the midline (parietal length 4.4–4.9, mean 4.6 ± 0.19, n = 4 in *M. thomasi*; 5.9–6.4, mean 6.1 ± 0.17, n = 5 in *M. monticola*), the parietal-occipital suture is more dorsally positioned, and a supraoccipital crest is present, unlike *M. monticola*. The mandible of *M. thomasi* is larger and more robust than that of *M. monticola*. There are few differences in the dentition of these two species, both of which have unusually large upper and lower first premolars (a character previously considered to be diagnostic of *M. thomasi*), except that p4 is trenchant in *M. thomasi* but anteroflexed in *M. monticola*; the hypoconid of m3 is prominent in *M. thomasi* but low in *M. monticola*, which also differs in having a narrower talonid basin. In the single specimens of each species in which the dentition is deciduous, there is a trace of an anterior cuspid on di3 in *M. thomasi*, which is absent in *M. monticola*, whereas a metaconid is well developed on dp3 in *M. thomasi* but reduced to a trace in *M. monticola*.

MEASUREMENTS—External and cranial measurements are presented in Table 10-1.

VARIATION—There is no evidence of substantial variation within this small sample.

POPULATION STRUCTURE AND REPRODUCTION—The sample contained six adults with a male-to-female ratio of 1:5, plus a single infant with the deciduous dentition still erupting. The adult male had testes measuring 5 × 5 mm with convoluted epididymides. One of the adult females contained a single embryo in the right oviduct measuring 6 mm in crown to rump length. Mammary formula: 1-0-2 (n = 4); 0-1-2 (n = 1).

REMARKS—At 1550 m elevation, a specimen of *Microgale monticola* was captured in a Sherman trap placed on the ground at the opening of a cavity in the roots of a small tree.

Ecological Analysis

General

A total of 1,045 pitfall bucket-days was accrued during the small mammal survey of the eastern slopes of the RS d'Anjanaharibe-Sud, between 19 October and 30 November 1994, comprising 319 bucket-days at 875 m, 264 at 1260 m, 231 at 1550 m, and 231 at 1950 m (Table 10-3). Seventy-four small mammals were captured, including 68 *Microgale*, four *Setifer*, and two *Gymnuromys roberti* (Major, 1896a) (for rodents, see Chapter 12). Furthermore, 2,550 trap-nights using small mammal traps were also accrued (Chapter 12), and 13 (0.51%) Tenrecidae were captured. All species of *Microgale* recorded during the survey were captured in the pitfall traps, and five species of *Microgale* (*M. longicaudata*, *M. monticola*, *M. gymnorhyncha*, *M. dobsoni*, and *M. talazaci*) as well as *Setifer* were also trapped in standard live mammal traps. At 1550 m, seven species of *Microgale* were captured, two of which (*M. longicaudata* and *M. talazaci*) were trapped only in standard live traps. In the other three elevational zones, the species taken in live traps comprised a subset of those obtained in pitfall traps.

The combined trapping results, with pitfall and

TABLE 10-3. Characteristics and capture results of small mammals obtained in all pitfall lines.

Character	1	2	3	4	5	6	7	8	9	10	11	12
	Line											
Descriptive information												
Forest type	Lowland 875 m			Montane 1260 m			Upper montane 1550 m			Upper montane 1950 m		
Altitude, m	890	850	850	1250	1230	1240	1550	1510	1500	1970	1930	1950
Line placement*	R	V	S	R	V	S	R	V	S	R	V	S
First sample day (day/month)	19/10	19/10	20/10	4/11	4/11	4/11	15/11	15/11	15/11	24/11	24/11	24/11
Last sample day (day/month)	28/10	28/10	28/10	10/11	10/11	10/11	21/11	21/11	21/11	30/11	30/11	30/11
Total trap-days	110	110	99	88	88	88	77	77	77	77	77	77
Species sampled												
Mammalia												
Setifer setosus	2		2									
Microgale cowani					4		3	6	4	2	3	4
Microgale longicaudata				1	1					1		1
Microgale principula	3											
Microgale parvula						2		1			1	1
Microgale dobsoni				4	3	1						
Microgale talazaci				1	3							
Microgale soricoides				3		2		1				
Microgale gymnorhyncha					1			2	1			
Microgale monticola								2	2	2	1	
Gymnuromys roberti					1	1						
Mammal capture results												
Total number of captures	5	0	2	9	13	6	3	12	7	5	5	6
Total number of species	2	0	1	4	6	4	1	5	3	3	3	3
Capture success, %	4.5	0.0	2.0	10.2	14.8	6.8	3.9	15.6	9.1	6.5	6.5	7.8
Total number of *Microgale* captured	3	0	0	9	12	5	3	12	7	5	5	6
Total number of *Microgale* species	1	0	0	4	5	3	1	5	3	3	3	3
Microgale capture success, %	2.7	0.0	0.0	10.2	13.6	5.7	3.9	15.6	9.1	6.5	6.5	7.8

* R = ridge; S = slope; and V = valley.

standard live traps, include 10 species of Tenrecidae (*Setifer* and nine species of *Microgale*). None of the *Microgale* had been recorded previously in the reserve, and one is proposed herein as new to science. Before proceeding with the analysis of the trapping results, it is important to determine whether the sampling effort was sufficient to reflect some measure of completeness for the survey and the actual tenrecid species richness within each elevational zone.

Species Accumulation Curves

By plotting the total number of species known from each pitfall line (11 pitfall buckets per 24 hr period) or elevational zone (33 pitfall buckets per 24 hr period), species accumulation curves may be drawn. An examination of these curves (Fig. 10-5) shows that no additional species of *Microgale* was added in the 875 m zone after 66 pitfall bucket-days (total, two species in 319 pitfall bucket-days), in the 1260 m zone after 165 pitfall bucket-days (total, seven species in 264 pitfall bucket-days), in the 1550 m zone after 198 pitfall bucket-days (total, five species in 231 pitfall bucket-days; two other species only in standard live traps), and in the 1625 m zone after 99 pitfall bucket-days (total, four species in 231 pitfall bucket-days). The flattening of the species accumulation curve within each elevational zone with additional trapping effort did not generally coincide with a general decline in overall pitfall trap success (Fig. 10-5). However, the number of insectivores captured in each elevational zone tended to decline during the time that the lines were in place.

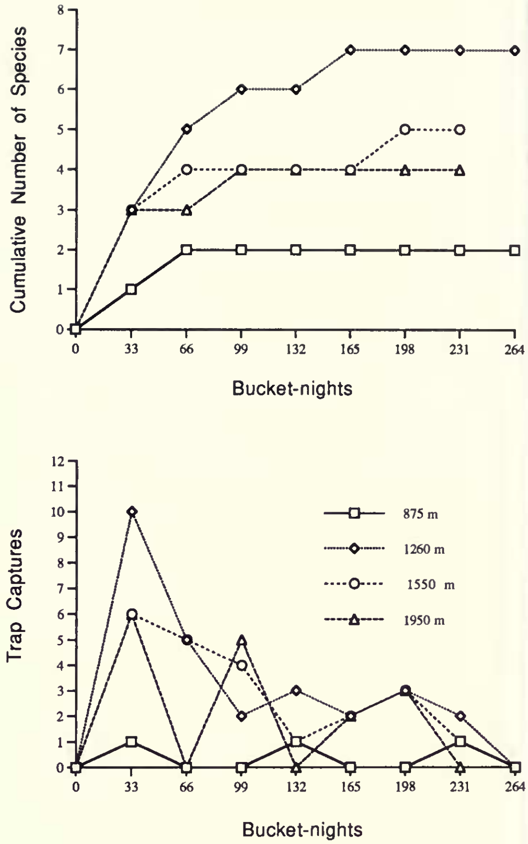

FIG. 5. Species accumulation curves (**top**) and pitfall trap success (**bottom**) plotted for each elevational zone against the total number of bucket-nights. Information from the three lines in each zone is combined.

Trapping Success and Abundance

The results of the pitfall trapping are presented in Table 10-3. In each elevational zone, three pitfall lines were in use for a minimum of 7 days, and there was considerable variation in the capture rate of insectivores within and between the lines. For *Microgale* at 875 m, the capture success rate for the three lines varied from 0 to 2.7%; at 1250 m, from 6.8 to 13.6%; at 1550 m, from 3.9 to 15.6%; and at 1950 m, from 6.5 to 7.8%.

One important question concerns our sampling protocol: Do trapping results reflect the relative abundance of the various *Microgale* in the reserve during the survey? A response is not simple. However, because the lines were placed randomly in a variety of microhabitats within each elevational zone, because partially arboreal species are regularly captured in the pitfall buckets and we have no evidence of strictly arboreal tenrecs, and because our species-accumulation curves generally reached an asymptote after a few days and further trapping efforts generally did not result in additional new species to the elevational list, we believe that our results are a good first approximation of relative species richness and general abundance of small insectivores within the reserve during the season of our study. Furthermore, other studies of Malagasy insectivores using pitfall traps indicate that this technique is most efficient for documenting species richness in eastern humid forest (Raxworthy & Nussbaum, 1994; Goodman et al., 1996).

Relationship between Abiotic Factors and Insectivore Capture Rates

Information was gathered in the RS d'Anjanaharibe-Sud at each site on daily minimum and maximum temperatures as well as precipitation (see Chapter 1). To determine whether Insectivora capture rates, particularly *Microgale*, were influenced by these climatic factors, a series of nonparametric Kendall's rank correlations were made. In these, the *Y* variable was the number of animals captured, and the *X* variable was the minimum temperature the morning the line was checked, the maximum temperature the previous afternoon, and the amount of precipitation during the previous 24 and 48 hr periods. In no case was any of these variables correlated to insectivore trap success.

Species Diversity

On the basis of our trapping results, there is a clear indication of variation in the elevational ranges of many of the tenrecs on the slopes of the reserve. A total of 10 Insectivora (*Setifer* and nine *Microgale* species) were captured during the 1994 survey of the reserve using two trapping techniques, pitfall and standard live traps. No evidence of the two Soricidae, *Suncus madagascariensis* or the introduced *Suncus murinus*, was found in the reserve.

The number of Tenrecidae known in each elevational zone (with the number of *Microgale* in parentheses) is as follows: 875 m, three (one); 1260 m, eight (seven); 1550 m, seven (seven); and 1950 m, four (four) species (Table 10-4). Thus, for the genus *Microgale*, there appears to be a midelevational peak in species richness between 1260 and 1550 m. A parallel pattern was found in the RNI d'Andringitra (Goodman et al., 1996).

No species of Insectivora was found across the breadth of the elevational transect. This is in contrast to the RNI d'Andringitra, where two species (*Microgale taiva* and *M. parvula*), and probably a third species (*M. longicaudata*), occurred across the complete elevational transect between 720 and 1625 m (Goodman et al., 1996). On the basis of our trapping results in the RS d'Anjanaharibe-Sud, two tenrecs (*Setifer* and *M. principula*) are confined to lowland forests at 875 m, and one (*M. dobsoni*) is confined to montane forest at 1260 m. The other species of *Microgale* have relatively broad distributions in the montane and upper montane forest zones.

TABLE 10-4. Known elevational distribution of Tenrecidae on the eastern slopes of the RS d'Anjanaharibe-Sud.*

Species	Elevational range 875 m	1260 m	1550 m	1950 m
Setifer setosus	+	–	–	–
Tenrec ecaudatus	(+)	(+)	–	–
Microgale cowani	–	+	+	+
Microgale longicaudata	–	+	+	+
Microgale principula	+	–	–	–
Microgale parvula	–	+	+	+
Microgale dobsoni	–	+	–	–
Microgale talazaci	–	+	+	–
Microgale soricoides	–	+	+	–
Microgale gymnorhyncha	–	+	+	–
Microgale monticola	–	–	+	+
Total number of Insectivora	3	8	7	4
Total number of *Microgale* spp.	1	7	7	4
Microgale spp. in each zone, %	10	70	70	40

* Includes sight records (in parentheses) and records of species obtained in live traps and pitfall traps from the 1994 survey.

In general our measures of *Microgale* species richness in each elevational zone parallel total capture rates. Thus, the greatest pitfall capture rates were at 1260 m (27 individuals) and 1550 m (22 individuals), followed by 1950 m (16 individuals) and finally 875 m (three individuals) (Table 10-3). The single exception was *M. cowani*, which did not follow this pattern; it was most common at 1550 m (13 individuals), followed by 1950 m (nine individuals), then 1260 m (four individuals).

Habitat Separation

Within each elevational zone pitfall lines were installed in three different habitats: ridges, valley bottoms, and on hill or slope crests. An analysis of the pitfall trapping results segregated by these habitat variables allows us to speculate on possible differences in microhabitat utilization by different species of *Microgale*. Of the 68 *Microgale* trapped in pitfall buckets, 20 were obtained on ridges, 30 in valleys, and 17 on slopes (Table 10-3). Although these differences are not statistically significant, there appears to be a tendency for more individuals of this genus to occur in valley bottoms. Furthermore, a total of seven species were captured on ridges, eight in valley bottoms, and six on slopes (Table 10-5). Thus, in general, relative density and species richness appear to be highest in valleys, followed by ridges, and lowest on slopes. In the RNI d'Andringitra, the highest density of soil invertebrates was likewise found in valleys, followed by ridges, and finally slopes (Goodman et al., 1996). When analyzed by species, the same general pattern exists for some taxa, but within elevational zones there is considerable variation (Table 10-5). In all elevational zones, *M. cowani* was more common in valleys than the other microhabitats, the only exception being at 1950 m, where 33% were taken in valleys as compared with 44% on slopes. *Microgale gymnorhyncha* and *M. monticola* were also more common in valleys than the other two microhabitats, whereas species such as *M. principula* and *M. dobsoni* were exclusively or generally trapped on slopes. *Microgale longicaudata* was evenly distributed between ridges and valleys.

Ecological Separation

On the basis of their very long tail with a prehensile tip, elongated hindfoot, and similar dentition, *M. longicaudata* and *M. principula* are either closely related within the *Microgale* clade or ecological counterparts of one another. It is now known that *M. longicaudata* is partially arboreal, as is presumably *M. principula*. To our knowledge, the co-occurrence of these two species observed on the slopes of the RS d'Anjanaharibe-Sud is the first record of these species in the same forest. Interestingly enough, they were not found in direct sympatry, but rather *M. principula* was only in the 875 m zone, and *M. longicaudata* occurred higher on the mountain.

A parallel case of morphological similarity may be made for *Microgale talazaci* and *M. dobsoni*, particularly in body size, tail proportions, and cranial and dental structure. In this case, however, they partially overlapped in elevational range; the former species was found in the 1260 and 1550 m zones, and the latter only at 1260 m.

The variation in morphology of the other species of *Microgale* collected from RS d'Anjanaharibe-Sud suggests some ecological separation. The very small size of *M. parvula* implies a distinct life strategy; the specialized dentition, modified rhinarium, and broad forefeet of *M. gymnor-*

TABLE 10-5. Microhabitat differences in the occurrence of *Microgale* on the slopes of the RS d'Anjanaharibe-Sud.*

Species	Elevational zone†														
	875 m			1260 m			1550 m			1950 m			Combined		
	R	V	S	R	V	S	R	V	S	R	V	S	R	V	S
Microgale cowani					100		23	46	31	22	33	44	19	50	31
Microgale longicaudata				50	50					50		50	50		50
Microgale principula	100												100		
Microgale parvula						100		100			50	50		40	60
Microgale dobsoni				50	38	13							50	38	13
Microgale talazaci				25	75								25	75	
Microgale soricoides				60		40		100					50	17	33
Microgale gymnorhyncha					100			66	33					75	25
Microgale monticola								50	50	66	33		28	29	43
Total *Microgale* captures, %	100	0	0	33	42	25	11	56	33	33	33	33	29	38	33
Number of *Microgale* spp.	1	0	0	4	5	3	1	5	3	3	3	3	6	8	7

* Figures presented as the percent capture (rounded) of *Microgale* species within each elevational zone.
† R = ridge; S = slope; and V = valley.

hyncha suggest a considerable difference in ecology (possibly ground dwelling and conceivably semifossorial) from that of *M. soricoides*, with its slender feet (possibly more scansorial) and equally specialized but different dentition. The other two species with an apparently unspecialized dentition and body form, *M. cowani* and *M. monticola*, nevertheless differ in external size and proportions and, presumably, lifestyle.

Discussion

In general, the vast majority of *Microgale* species expected to occur within the reserve on the basis of their known distribution in the northern portion of the eastern humid forests were captured during the 1994 biological inventory of the RS d'Anjanaharibe-Sud. There are a few notable exceptions that warrant some discussion here.

Microgale drouhardi (Grandidier, 1934), including *M. melanorrhachis* (Morrison-Scott, 1948; see Jenkins et al., 1997), is a widespread species known from areas north of the RS d'Anjanaharibe-Sud (PN de la Montagne d'Ambre) and south to the RNI d'Andringitra. However, this species has a patchy distribution and generally is locally common. Thus, the absence of this species from our samples taken in the RS d'Anjanaharibe-Sud probably reflects its actual absence from the reserve. Two other *Microgale* are known from the eastern humid forest yet were not captured in the RS d'Anjanaharibe-Sud, *M. thomasi* (Major, 1896a), a species rare in collections and recorded mainly from areas farther south in the eastern humid forest, and *M. pusilla*, another species with apparently widely disjunct populations and a patchy distribution (MacPhee, 1987). The absence of the latter species is surprising in view of its documented presence in the nearby RNI de Marojejy (Nicoll & Langrand, 1989).

Within the endemic Insectivora there are a few other distributional anomalies. During our inventory of the reserve, we found no evidence of *Hemicentetes* (Mivart, 1871) or *Oryzorictes* (Grandidier, 1870). However, during a survey of the western slopes of the RS d'Anjanaharibe-Sud conducted by Franco Andreone between 25 February and 12 February 1996 within the elevational range of 1000–1300 m, *Hemicentetes* was observed and photographed, and *Oryzorictes talpoides* G. Grandidier & Petit, 1930, *Microgale taiva* (Major, 1896b), and *M. fotsifotsy* Jenkins et al., 1997 were captured using pitfall techniques. The vegetation of the western slopes of the reserve is similar to that of the eastern slopes, although the former may receive less annual precipitation. It is not clear whether these species occur on the eastern slopes of the reserve and were overlooked during the 1994 survey. Furthermore, no *Tenrec ecaudatus* was captured during the 1994 inventory, although several individuals were observed at night in the 875 and 1260 m altitudinal zones. Another interesting record is that of *M. dryas* (Jenkins, 1992), which is based on the fragments of a skull (probably a single juvenile specimen) included in a *Tyto soumagnei* (Madagascar Red Owl) pellet collected at the edge of the reserve at Antsahamifelana (14°46'S, 49°28'E). Combining all sources of information, 16 species of Insectivora have been recorded within the reserve, 12 of which belong to the genus *Microgale*.

On the basis of the species-accumulation curves for each elevational zone and extrapolation of what should presumably occur in the reserve and what was found, we conclude that the Insectivora fauna, particularly species of *Microgale*, on the eastern slopes of the RS d'Anjanaharibe-Sud has been thoroughly, although not completely, surveyed.

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Appendix 10-1.

Key to the Genera of Tenrecidae Occurring at RS d'Anjanahribe-Sud.

1. Pelage spinous; tail very short 2

   Pelage soft, lacking spines; tail medium to long 4

2. Closely set, sharp spines cover dorsal surface . . . . *Setifer*

   Dorsal surface covered with a mixture of spines and long, coarse hair 3

3. Dorsal pelage dark with longitudinal pale stripes; head and body length <200 mm . . . . *Hemicentetes*

   Dorsal pelage uniform brown; head and body length >260 mm . . . . *Tenrec*

4. Body robust, forelimbs robust, forefeet broad with enlarged, stout claws; upper canine longer than first upper incisor . . . . *Oryzorictes*

   Body slender to moderately robust, forelimbs not enlarged, forefeet slender to moderately broad, claws short to moderately lengthened; first upper incisor longer or subequal in length to upper canine . . . . *Microgale*

Appendix 10-2.

Key to the Species of *Microgale* Occurring at RS d'Anjanaharibe-Sud.

1. Size very small, HB < 62 mm, CIL < 16.9 mm . . . . *M. parvula*

   Size larger, HB > 65 mm, CIL > 19.0 mm 2

2. Ratio of TL:HB > 2.0 3

   Ratio of TL:HB < 1.5 4

3. Size smaller, HB < 75 mm, CIL < 21.6 mm . . . . *M. longicaudata*

   Size larger, HB > 78 mm, CIL > 22.5 mm . . . .*M. principula*

4. Digits and tail tip contrastingly paler than body, tail, and feet . . . .*M. fotsifotsy*

   Tail tip and digits not obviously paler than rest of body 5

5. Proboscis long, large rhinarium extends posterodorsally onto muzzle; forefeet broad, foreclaws enlarged . . . . *M. gymnorhyncha*

   Small rhinarium confined to anterior of short proboscis; forefeet slender without lengthened foreclaws 6

6. Tail markedly bicolored; ratio of TL:HB < 0.9 . . . . *M. cowani*

   Tail not markedly bicolored; ratio of TL:HB > 0.9 7

7. Body size smaller, HB < 75 mm . . *M. taiva*

   Body size larger, HB > 75 mm 8

8. Cranial size smaller, CIL < 26.5 mm; body size averaging smaller, HB <104 mm 9

   Cranial size larger, CIL > 28.5 mm; body size averaging larger, HB > 99 mm 10

9. Pelage dark brown dorsally, slightly lighter ventrally; TL longer than HB, ratio > 1.2 . . . .*M. monticola*

   Pelage lightish buff brown dorsally, reddish buff ventrally; TL subequal to HB, ratio < 1.1 . . . .*M. soricoides*

10. Cranial size smaller, CIL < 32.0; body size averaging smaller, HB < 112 mm, WT < 31 g . . . .*M. dobsoni*

    Cranial size larger, CIL > 34.5; body size averaging larger, HB > 106 mm, WT > 31 g . . . .*M. talazaci*